Life Cycle Management (Subject Editor: Gerald Rebitzer)

Life Cycle Approach in the Procurement Process: The Case of Defence Materiel

Elisabeth Hochschorner[1,2]* and Göran Finnveden[1,3]

[1] Environmental Strategies Research – fms, Dept. of Infrastructure, Royal Institute of Technology (KTH), 100 44 Stockholm, Sweden
[2] Industrial Ecology, Dept. of Chemical Engineering, Royal Institute of Technology (KTH), 100 44 Stockholm, Sweden
[3] Swedish Defence Research Agency, Stockholm, Sweden

* **Corresponding author** (elisabeth.hochschorner@infra.kth.se)

DOI: http://dx.doi.org/10.1055/lca2005.10.230

Abstract

Goal, Scope and Background. Procurement in public and non-public organisations has the potential to influence product development towards more environmentally friendly products. This article focuses on public procurement with procurement in Swedish defence as a special case. In 2003, public procurement in Sweden was 28% of the GDP. In the Swedish defence sector the amount was 2% of the GDP. The total emissions from the sector were of the same order of magnitude as from waste treatment (2% of Sweden's emissions). According to an appropriation letter from the Ministry of Defence in 1998, the Swedish Armed Forces (SAF) and the Swedish Defence Materiel Administration (FMV) are required to take environmental issues into consideration during the entire process of acquiring defence materiel. Environmental aspects are considered today, but without a life-cycle perspective.
The aims of this article are to recommend suitable tools for taking environmental concerns into account, considering a product's life-cycle, in the procurement process for defence materiel in Sweden; to make suggestions for how these tools could be used in the acquisition process; and to evaluate these suggestions through interviews with actors in the acquisition process. The procurement process does not include aspects specific to Swedish defence, and it is therefore likely to be comparable to processes in other countries.

Methods. The method involved a study of current literature and interviews with various actors in the acquisition process. The life cycle methods considered were quantitative Life Cycle Assessments, a simplified LCA-method called the MECO method and Life Cycle Costing (LCC).

Results and Discussion. Methodology recommendations for quantitative LCA and simplified LCA are presented in the article, as well as suggestions on how to integrate LCA methods in the acquisition process. We identified four areas for use for LCA in the acquisition process: to learn about environmental aspects of the product; to fulfil requirements from customers; to set environmental requirements and to choose between alternatives. Therefore, tools such as LCAs are useful in several steps in the acquisition process.

Conclusion. From the interviews, it became clear that the actors in the acquisition process think that environmental aspects should be included early in the process. The actors are interested in using LCA methods, but there is a need for an initiative from one or several of them if the method is to be used regularly in the process. Environmental and acquisition issues are handled with very little interaction in the controlling and ordering organisation. An integration of environmental and acquisition parts in these organisations is probably needed in order to integrate environmental aspects in general and life-cycle thinking in particular. Other difficulties identified are costs and time constraints.

Recommendation and Perspective. In order to include the most significant aspects when procuring materiel, it is important to consider the whole life-cycle of the products. Our major recommendation is that the defence sector should work systematically through different product groups. For each product group, quantitative, traditional LCAs or simplified LCAs (in this case modified MECOs) should be performed for reference products within each product group. The results should be an identification of critical aspects in the life-cycles of the products. The studies will also form a database that can be used when making new LCAs. This knowledge should then be used when writing specifications of what to procure and setting criteria for procurement. The reports should be publicly available to allow reviews and discussions of results. To make the work more cost-effective, international co-operation should be sought. In addition, LCAs can also be performed as an integrated part of the acquisition process in specific cases.

Keywords: Acquisition; defence materiel; integrated product policy; life cycle costing (LCC); life cycle management (LCM); MECO-method (simplified LCA-method); public procurement

Introduction

Most products in society generate environmental impacts in all phases of their life-cycle, as they consume raw materiels and energy, release emissions and produce waste. In some countries there is a statutory responsibility for producers to prevent environmental impacts from certain products. Nevertheless their customers, e.g. the procuring organisation, can be a considerable driving force for more environmentally friendly products through their choice of and requirements for products. By requiring that products meet certain environmental criteria the procuring organisation has the opportunity to influence products so that they are more environmentally friendly. However, a number of obstacles make it difficult for procurement to happen in a way that exerts environmentally friendly influences. For example, environmental requirements in public procurement are not always stipulated (Swedish EPA 2005, Jonsson 2004) or formulated in a sufficient way (Faith-Ell 2005, Jonsson 2004). The pos-

sibility of taking environmental issues into consideration when procuring materiel can be limited by lack of reliable information about the environmental characteristics of the product or service (OECD 2000). Different types of tools can contribute some knowledge and thereby facilitate the choice of environmentally preferable products, e.g. eco-labels, guidelines, checklists and tools for environmental assessment. When stipulating environmental requirements it is important to have a life-cycle perspective, in order not to miss essential aspects in the life of products (e.g. COM 2001a, 2003). Therefore, it is important that the supporting tool also has a life-cycle perspective. It is stated in COM (2003) that Life Cycle Assessments (LCAs) are important support tools since they are the best (currently available) frameworks for assessing environmental impacts from products.

Use of LCA-based approaches in procurement is limited today (Baumann and Tillman 2004) and there are few publications on LCA and procurement, and even fewer on LCA and public procurement. The current scientific literature on environmental procurement mostly covers marketing, such as environmental labelling (e.g. Baldo et al. 2002), or use of environmental management systems (Chen 2005). The present paper contributes new aspects to the current scientific literature, since the focus is the use of Life Cycle Assessments in public procurement, with procurement in Swedish defence as a special case. The considered procurement process does not include aspects specific to Swedish defence, and therefore it is likely to be comparable to processes in other countries. In 2003, public procurement in Sweden was 28% of the GDP (SCB 2004). In the Swedish defence sector the amount was 2% of the GDP (Finnveden et al. 2002). The total emissions (direct and indirect emissions) from the sector were of the same order of magnitude as from waste treatment (2% of Sweden's emissions) (Finnveden et al. 2002, Finnveden et al. 2005). This illustrates that military procurement deserves to be taken as seriously as an environmental impact as waste treatment.

Today the environmental demands on all activities in society are increasing; the defence sector is not an exception. In Sweden, environmental demands on the defence sector, for example, are given in the sectoral responsibility and appropriation letters from the Government. There is a rising need to evaluate and to limit the effects that defence activities and materiels used in defence have on the environment. Defence materiel covers a wide range of different products, such as plants, animals, food, refrigerators, office supplies, computers, medicine, tools, engines, GPS, ammunition, furniture, clothes, chemicals, vehicles, aeroplanes, ships, boats, and tanks. The materiel includes both products developed especially for defence purposes (e.g. ammunition, tanks) and products used in other sectors (e.g. computers, tools). For the first type of product, the actual production process is sometimes a part of the acquisition process and is carried out in dialogue with the defence authorities and the industry. Working with environmental issues of defence materiel sometimes provokes reactions. However, it can be noted that for some products, e.g. ammunition, only about 5% of these products are actually used during practice in Sweden (Hägvall, pers. comm.). The remaining 95% are sent for destruction after storage. According to an appropriation letter from the Ministry of Defence in 1998, the Swedish Armed Forces (SAF) and the Swedish Defence Materiel Administration (FMV) are required to take environmental considerations into account during the whole process of acquiring defence materiel (SAF 2001). Environmental aspects are considered today, but without a life-cycle perspective. The importance of taking environmental issues with a life-cycle perspective into consideration, however, has been stressed by both SAF and FMV.

This article presents a part of a larger project. The overall aim of the project is to make suggestions on how to give consideration to environmental matters with a life-cycle perspective in the acquisition process of defence materiel in Sweden. Various parts of the project have been to: review and analyse simplified tools for taking environmental considerations into account (Byggeth and Hochschorner 2005); compare and evaluate methods for simplified Life Cycle Assessment (Hochschorner and Finnveden 2003a); and to make an LCA study of a military materiel (Hochschorner et al. 2005). The work presented here considers the last three parts of the project: to recommend suitable tools for environmentally preferable procurement of defence materiel in Sweden; to make suggestions for how these tools could be used in the acquisition process; and to evaluate these suggestions through dialogue with actors in the acquisition process.

Terminology. In the literature the terms acquisition, procurement and purchasing are used. The term 'acquisition process' is used here to describe the process of acquiring defence materiel. This process includes a phase called 'procurement'. 'Procurement' is used to describe the phase in the acquisition process where the materiel is bought (where 'materiel' is materiels, services and equipment) and also as a more general term than acquisition. In order to distinguish between the different terms, the term purchasing is omitted here.

1 Study Method

The method consisted of literature studies and interviews with different actors in the acquisition process. Literature studies included literature on public procurement, procurement in defence, and literature on strategies for integrating environmental considerations into procurement. Based on a study of the literature, a preliminary suggestion on how to integrate environmental considerations with a life-cycle perspective in the Swedish defence was made (Hochschorner and Finnveden 2003b). Interviews were carried out with personnel from environmental and/or procurement units at the Ministry of Defence, SAF, FMV and three defence industries, in order to evaluate our preliminary suggestions and to better understand their roles in the acquisition process. The interview questions are included in Hochschorner and Finnveden (2004). The interviews led us to our final proposals, presented in this article. For the final suggestions, experiences from the LCA study on a military product were also used in the process. The LCA study was done on a pre-fragmented high explosive shell grenade, using both a traditional quantitative LCA and a simplified LCA. The results are presented in Hochschorner et al. (2005).

2 Procurement

2.1 Procurement in public organisations

Procurement is when products or services are bought, leased or rented. This occurs in both public and private organisations. Due to differences in laws and regulations, procurement in public organisations and the possibility to take environmental considerations into account is somewhat different from that in non-public organisations. Some of the other differences from non-public organisations are (OECD 2000):

- Public procurement involves many participants in the decision, e.g. the use of the product or service may be in a different organisation from the procuring organisation.
- Considerable quantities may be involved.
- The process is highly structured and formalised.

Contracting should be a result of a competitive tendering procedure, starting with a call-for-tender. The call-for-tender includes specifications on bidders and products and can be open or restricted. Requirements on the products or services are entered in the tendering specifications, which also should include criteria for selection and award of the contract. Selection criteria must be based on the economic capability of the bidders and/or technical specifications. These are used to screen bids in a first review process. Environmental requirements can be formulated as part of the technical requirements in the call for tenders (The European Green Purchasing Network 2003).

2.2 Strategies for integrating environmental considerations into procurement

Public procurement in the European Union (EU) over a certain threshold is controlled by EU directives. The main opportunities for environmentally preferable public procurement are when deciding on the subject matter of a contract. These decisions are not covered by the rules of the public procurement directives, but are covered by the Treaty rules and principles on the freedom of goods and services, notably the principles of non-discrimination and proportionality. Contracts that are not covered by the directives have a considerably larger freedom to impose desirable requirements. In such cases, the procurement authorities are free to impose requirements and define conditions that go beyond what is possible under the public procurement directives (COM 2001a).

The Commission of the European Communities has issued an interpretative communication on the possibilities for integrating environmental considerations into public procurement (COM 2001a), on which this description of environmental consideration in public procurement is based. Contracts that are covered by the directives have two options for awarding the contract: the lowest price and the most economically advantageous tender. For the latter, the principle of non-discrimination has to be observed and the criteria applied must generate an economic advantage for the contracting authority (COM 2001a). It is possible to include prescriptions of primary materiels, production process, ECO-labels and use of variants in the technical specification, in cases where the subject matter of the contract may not be sufficiently precise and clear to all parties concerned. Such indications must be non-discriminatory and must always be accompanied by the terms 'or equivalent'. Economic considerations can include aspects of environmental protection, for instance the energy consumption of a product (COM 2001a).

Costs incurred during the life-cycle of a product which will be borne by the contracting authority may be taken into account in the assessment of the most economically advantageous tender. When evaluating tenders, a procurement organisation can also take into account costs for treatment of waste or recycling. As a general rule, externalities are not borne by the procurer of a product or service, but by the society as a whole and therefore do not qualify as award criteria. The Commission notes in this respect that contracting authorities retain the ability to take environmental consideration linked to eventual occurrence of external costs into account when defining the subject matter of a contract or when imposing conditions relating to the execution of the contract (COM 2001a).

Various strategies or means are available for integrating environmental considerations into procurement. Examples include choosing products with eco-labels, requiring that the suppliers have Environmental Management Systems (EMS) or using various tools depending on circumstances. Tools can be used in two different ways for procurement purposes, so-called supplier selection or product selection (Baumann and Tillman 2004). In supplier selection, suppliers are compared. In product selection, tools can be used to analyse and compare products and thereby choose the supplier. In this article a product selection approach considering the life-cycles of products was assumed. If the former approach had been assumed, our suggestions would have been different.

Life Cycle Assessments are considered here, since these analyse products and have a life-cycle perspective. Since acquisition of defence materiel can include the actual production of the materiel to be bought, it is important to use a tool that can also give guidance for environmentally preferable production and that considers the whole life-cycle of the product. LCAs have previously been used for procurement purposes. For example, the use of LCA for building materiels is described in Baldo et al. (2002) and Lippiat and Boyles (2001). Baldo et al. (2002) use LCA to find criteria for eco-labels. In Lippiat and Boyles (2001), a tool combining LCA and LCC for measuring environmental performance of building products is described.

2.3 Acquisition in Swedish defence

Acquisition in Swedish defence is an example of public procurement. The acquisition process is defined here in seven steps: studies, development, procurement, production, operation, phasing out and disposal, as described below. The description of the process is based on several sources (SAF 1997, OECD 2000, Defense Acquisition University 2001) and information from actors in the acquisition process. Materiel can be bought in the form of ready-made products, so-called direct procurement, or products that are de-

veloped as part of the acquisition process, so-called step-by-step procurement (SOU 2001). Step-by-step procurement is a special case of procurement, since it includes the actual production process. Direct procurement does not include development and production and can be seen as a more general procurement process.

The main actors in the Swedish acquisition process are: the Swedish Government (the Ministries of Defence, Finance and Foreign Affairs), which control the acquisition by appropriation letters, the Swedish Armed Forces (SAF), which order and use the materiel, the Swedish Materiel Acquisition Agency (FMV), which procures the materiel, and industry, which produces the materiel.

Step 1 – Studies. The first step is called studies. In this phase the procurement agency (FMV) is given an assignment of what to procure from SAF. General procurement requirements (environmental requirements included) are set in this step and further developed in later steps. The requirements on the product are developed in cooperation between FMV and SAF during the process, up to the procurement of the product (Wendel, pers. comm.).

Step 2 – Development. The second step includes design, development and tests of the materiel. Requirements on the product are further developed in this step. Development and tests are carried out by the industry, partly on behalf of FMV, partly as improvement strategies for the industry (Kinell, pers. comm.). When the product already exists on the market, development is not included in the acquisition process.

Step 3 – Procurement. The procurement step consists of three main activities:

- Selection: setting of criteria, invitation and supplier selection, proposal or offer application, and evaluation. The requirements developed during the second step are used in this phase.
- Contracting: The supplier(s) is (are) chosen and the agreement(s) is (are) made.
- Ordering: FMV orders the materiel from the industry.

Stept 4 – Production. The industry produces the materiel systems. FMV ensures that the materiel is delivered to their customer, SAF.

Step 5 – Operation. This step is the actual use phase and includes maintenance and support. During operation, the materiel is normally stored, used during practice, or used during international operations. The main responsibility for support and maintenance is on the Armed Forces.

Step 6 – Phasing Out. When the materiel is not going to be used any more, it is phased out of SAF's operation. FMV has the main responsibility for guaranteeing that this is done.

Step 7 – Disposal. The last step is the disposal step, where the materiel is recycled or sold. FMV has the main responsibility in the disposal phase.

3 Integrating Life Cycle Methods into the Acquisition Process

By life cycle methods we mean methods considering a product's life-cycle. Three methods are considered in this study: quantitative LCA, a simplified LCA method called the MECO method and Life Cycle Costing (LCC).

The term 'life-cycle' is used to indicate different things in LCA, LCC and when describing the life of a product in the acquisition process. For the sake of clarity, these differences are illustrated in **Fig. 1**. In LCA, the term life-cycle includes the mining of raw materiels, production, use and disposal of a product (i.e. from cradle to grave (ISO 1997), see the dashed line in Fig. 1). A different life-cycle is often used in LCC. In Woodward (1997), the following explanation of the life-cycle in LCC is made: "LCC of a physical asset begins when its acquisition is first considered, and ends when it is finally taken out of service for disposal or redeployment (where a new LCC begins)." For defence materiel in particular, research and development costs are often also in-

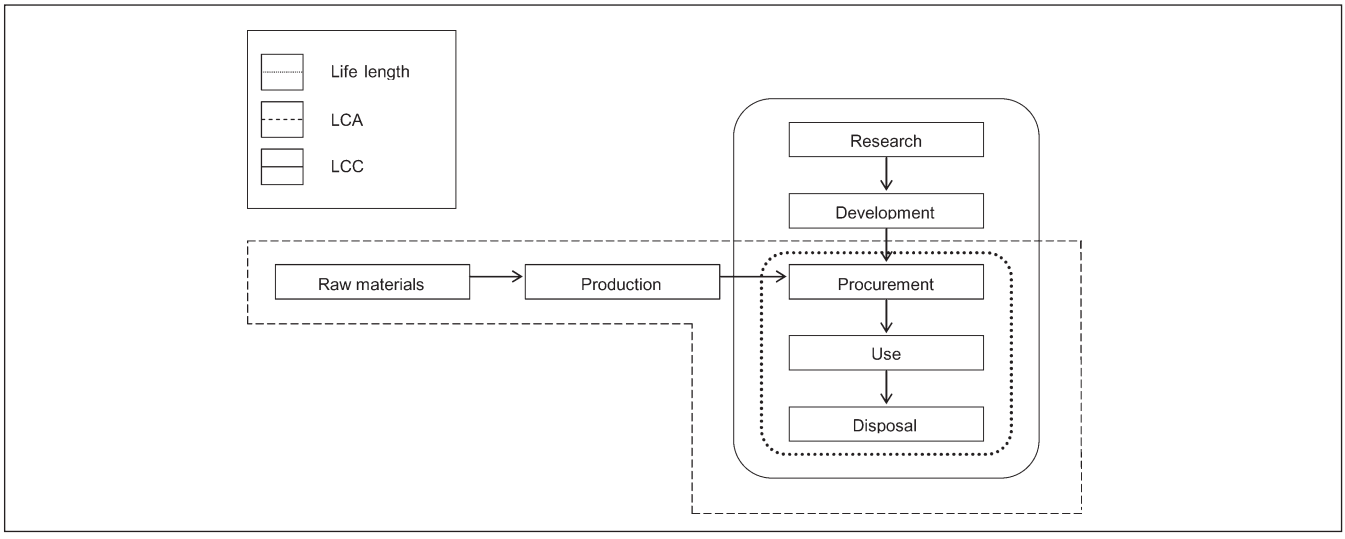

Fig. 1: Life-Cycles. The steps are examples and simplifications of what can be included (based on discussions with M. Overcash). The unbroken line describes typical system boundaries for LCC, the dashed line describes typical system boundaries for LCA and the dotted line typical boundaries for life length

cluded. This is illustrated by the unbroken line in Fig. 1. The actual time the product is used can be called the life length of the product (FMV 2002) and comprises the phases from procurement to disposal (see the dotted line in Fig. 1).

LCAs are not used today in the Swedish defence sector, but LCC is used to some extent as a basis for general procurement requirements, decisions on modifications or reconstructions, for choosing supplier and for evaluation of offers (FMV 2002). In the methodology used (FMV 2002) environmental costs are not included. There are different attempts to include environmental costs in LCC (see for example CWRT (2000) and Senthil et al. (2003)). Different types of environmental costs can be included in an LCC (e.g. direct, indirect, and external costs), using different monetisation methods. For one group of costs (the external costs) there are a large number of methods available for estimating them (Turner et al. 1994, Bocksteal et al. 2000). These methods also correspond to different types of external costs. A discussion is therefore necessary concerning which types of LCC are of interest and whether external costs are of interest, what type of external values should be included and which methods should be used to calculate them.

Experiences from LCAs of defence materiel are limited. However, it seems as though standard LCA methodology (ISO 1997, 1998, 2000a,b) and the recent handbook on LCA (Guinée et al. 2002) are also appropriate for LCAs on defence materiels (Hochschorner et al. 2004). There are, however, some aspects which may involve differences between military and non-military products. The use of defence materiel in war situations presents extraordinary difficulties for an LCA. Another difference concerns the type of materiels and chemicals used. Defence equipment may use specialized materiels and chemicals for which it is difficult to find data for the inventory analysis as well as the impact assessment steps. This was the case with our study (Hochschorner et al. 2004). Another difference concerns the exposure situation, which may be different to that for a normal consumer product. Defence materiel can also be stored and used over a very long time period, compared to many normal consumer products.

Since a quantitative LCA can be very time-consuming, it can be useful to perform a more simplified LCA study in the procurement process. There are a large number of simplified LCA-methods, see for example reviews in Christiansen (1997), Graedel (1998), Todd and Curran (1999) and Johansson et al. (2001). Two simplified LCAs, the Environmentally Responsible Product Assessment Matrix (Graedel and Allenby 1995) and the MECO method (Wenzel et al. 1997), were evaluated in an earlier project (Hochschorner and Finnveden 2003a) in order to find a suitable method for use in Swedish defence. These two methods were chosen since they are well documented and fundamentally different. The evaluation resulted in a recommendation to use the MECO method as a parallel complement, and/or as a pre-study to a traditional LCA (Hochschorner and Finnveden 2003a).

The name MECO comes from the first letter of the four categories (Materiel, Energy, Chemicals and Others) considered in the method. The method focuses on the life-cycle stages of materiel supply, manufacture, use, disposal and transport of the product. The original MECO method was developed by The Danish Institute for Product Development and dk-TEKNIK in co-operation with a larger Danish project and is described in Wenzel et al. (1997), Wenzel (1998) and Pommer et al. (2001). A modification of the method for use in the Swedish defence sector is described in full in Hochschorner and Finnveden (2004). The main differences from the original MECO method are the use of the thermodynamic approach (Finnveden and Östlund 1997) for characterisation of energy and materiel, using the so-called 50/50 method (Lindfors et al. 1995) for allocation, in the case of open-loop recycling, and using other lists (FMV 2003, Kemikalieinspektionen 2004, Nordic Council of Ministers 2004) for classification of Chemicals. In Pommer et al. (2001), there is a recommendation that all energy consumption be calculated as oil consumption. Instead, we recommend presenting renewable energy as renewable, when such is used, since the environmental impacts from renewable and non-renewable are different. More detailed descriptions and justifications for them are described in Hochschorner and Finnveden (2004).

Our previous studies have shown that the results from an MECO study complement a quantitative LCA by generating more information on the environmental and hazard risks of the substances and by the inclusion of qualitative information (Hochschorner and Finnveden 2003a). The assessment can identify critical aspects of the product, which is useful when deciding on environmental requirements for procurement. Another advantage of the MECO method is that the data needed to perform the analysis are not production-specific. This makes it easier for the procuring organisation to collect the required data.

The MECO method is useful as a stand-alone tool, but also as a pre-study and as a complement to a quantitative LCA. In the latter case we recommend that the analysis focus on the categories Chemicals and Others, since these categories generate information that is complementary to a quantitative LCA (as shown in Hochschorner and Finnveden 2003a). The chemicals included should be the same cradle-to-gate data used in the quantitative LCA (Hochschorner and Finnveden 2004). In this case it is not necessary to divide the chemicals into the life-cycle stages in the original MECO method, since the quantitative LCA will provide a presentation of chemicals in that way. The focus should lie on classifying them according to their toxicological effects.

4 Results

4.1 Life Cycle Assessment in the acquisition process

Life Cycle Assessments, simplified or quantitative, can be used in different ways in the acquisition process. The study can be ordered, made and used by different actors in different phases of the acquisition process. We have identified the following four areas for use of LCA in the acquisition process:

- Learning about environmental aspects of the product (useful for the user (here, SAF), procuring organisation (here, FMV) and the producer (here, industry)),

- Fulfilling requirements from customers (useful for the procuring organisation and the producer),
- Setting environmental requirements (useful for the user, procuring organisation and producer)
- Choosing between alternatives (useful for the user, procuring organisation and the producer).

The choice of method depends on different factors, such as the economy, time, type of product, and need for information. A major difference between traditional LCAs and simplified LCAs such as MECO is that the former is more suitable when choosing between alternatives, since a quantitative dimension is needed in order to compare. Simplified LCAs can primarily be used for identifying critical aspects (Hochschorner and Finnveden 2003a). This latter function is of relevance in the acquisition process and the MECO method can be useful when identifying critical aspects and setting requirements. When procuring materiel that is developed especially for the customer, a quantitative LCA to acquire knowledge of the life-cycle environmental impact of the product may be useful. If the product resembles a product for which an LCA has been performed, the existing LCA can be adjusted for the new product or the LCA data can be used in an MECO analysis. When the MECO method is used mainly as a complement to a quantitative LCA, the analysis should be made in the same steps as the quantitative LCA.

It would be advantageous if LCAs could be performed during the actual acquisition process, so the information could be used directly. But, since it can be too time-consuming or too expensive to perform a quantitative LCA, it can be useful to use data from existing LCAs. We have two suggestions on how to use LCAs in Swedish defence. The suggestions are results from the interview-based evaluation of the preliminary suggestions. One suggestion is to make LCAs on reference products, and use data from these studies in the acquisition process. The other suggestion is to make LCAs during the acquisition process. In both cases the LCA reports should be publicly available to allow reviews and discussions of results. To make the work cost-effective, international co-operation should be sought.

The reference products should, in some sense, be typical examples of products in different product groups, for example vehicles, ammunition and clothes. Definitions of product groups should be made by FMV and SAF in collaboration. Quantitative, comprehensive LCAs or simplified LCAs (in this case, modified MECOs) should be performed for reference products within each product group.

The results should be an identification of critical aspects in the life-cycles of the products. Since many parts of the products in the same product group can be the same or similar (e.g. the same metals in a group of vehicles) the results will form a database that can be used when making new analyses. The analyses should preferably be made with quantitative LCAs, in order to get an extensive database. The analysis can also be complemented with an MECO assessment. The database can then be used when performing a new LCA or an MECO assessment, when writing specifications of what to procure and when setting up environmental requirements.

LCAs can also be performed and used during the acquisition process. This is preferably done using data from LCAs on reference products. Performing a quantitative LCA or an MECO assessment in the acquisition process is preferably done in the study phase, since it is easier to influence the product and production early in the process. However, the product will frequently not be specified in sufficient detail to allow a detailed LCA early in the process. It may therefore be necessary to complete or perform the analysis later in the process, e.g. in the Development or Procurement step.

Data from quantitative LCAs can be used to facilitate a choice between different alternatives, for example materiels and processes, in the steps Studies, Development, Production, Operation and Disposal. The MECO assessment identifies environmentally critical aspects in the product's life; this information is useful when developing products in an environmentally preferable way. When using LCAs in the procurement step, a distinction can be made between two cases:

a) Setting up requirements
b) Choosing between suppliers

LCAs can be used for setting up requirements. However, it is not likely that LCAs can be used today for choosing between different suppliers. This is because it is not likely that the suppliers can provide the relevant information in this step, because of the time constraints during the procurement and because of the regulations for public procurement. In identifying critical aspects of products, it can be relevant to ask suppliers for specific information in this step, e.g. energy use and materiels.

A quantitative LCA or an MECO can also be performed in the Disposal step, to analyse different disposal strategies.

4.2 The actors' point of view

Interviews. The interview findings are presented in order to show how the preceding suggestions fit in with the real-life procurement process.

The industry. Personnel from environmental units at the industries Alvis Hägglunds AB (Ericson and Svedlund), Bofors Defence AB (Kinell) and Saab AB (Algotsson) were interviewed. According to these informants, these industries give some consideration to environmental matters when developing new products today, mostly by following legal requirements. If their customers require more consideration to be paid to environmental matters, this has to be indicated in the specification of requirements. The industry has some knowledge of LCA, but they had not heard about the MECO method before. They were interested in knowing more about the method, and all of them stressed the need for a simplified method. Algotsson considers a comprehensive LCA to be too complex and time-demanding to perform in current industry. Ericson and Svedlund suggest that it would be ad-

vantageous if all industries (in the same production field) could use the same method. No LCA methods are used regularly within the three industries today, but Saab AB has used simplified LCAs in special projects to compare present solutions with alternatives (Algotsson, pers. comm.). At Bofors Defence AB, a Master's thesis has been written on an LCA of one of their products (Edesgård and Eriksson 1999). Bofors Defence AB has bought the EPS system (an LCA method, for more information see Steen 1999) and taken courses in LCA in order to be prepared if one of their customers require an LCA (Kinell, pers. comm.). All interviewees were positive toward our suggestions on LCA in the acquisition process and about performing LCAs if this is requested and paid for by the customer (Ericson and Svedlund, Kinell, Algotsson, pers. comm.). They are also positive about cooperating with FMV and SAF if LCAs are to be made on reference products, with the restriction that some data may not be accessible.

FMV. FMV takes some environmental matters into consideration today, e.g. by restrictions on chemicals (FMV 2003), but without a life-cycle perspective. Some preparatory work on use of LCA has been carried out by the environmental unit (FMV 1999), but no LCAs have been performed. Wendel (pers. comm.), working with system security, reacts positively to our suggestion that LCAs be performed on reference products. He suggests that the responsibility for such analysis lies partly with FMV and partly with SAF. It would be the responsibility of FMV if stated by legislation, which it is not the case today. If it were a requirement from SAF, they would have to be prepared to meet the costs of the analysis. If LCAs are to be performed during the acquisition process, Wendel believes that this is preferably done during the study or development step, perhaps by working groups with members from FMV, SAF and the defence research industries. The environmental unit at FMV has shown interest in our suggestions and, in LCAs, especially simplified methods.

SAF. SAF gives some consideration to environmental matters today. The environmental unit has some knowledge of LCA, but they have not used the method. Hull (pers. comm.), who works at the order unit at SAF, thinks that it is possible to perform LCAs on reference products with some delimitation, since some data are more difficult to trace. Products developed a long time ago are controlled by a different legislation. Hull thinks that it can be difficult to perform LCAs in the disposal step, because of the long time since production of the materiel system. However, he believes that it is up to FMV to decide what methods they want to use. Hull also suggests that it can be in FMV's interest to use LCAs to verify the environmental work in the acquisition process. If the Ministry of Defence were to require that SAF demand LCA information on the products to acquire, then SAF would demand this from FMV. If LCAs are to be made on only some of the products, he thinks that SAF should be included in some kind of controlling group. If LCAs are to be made on almost all procured products, the responsibility should probably be FMVs.

The Ministry of Defence. Ohlin (pers. comm.), working at the military unit at the ministry of defence, points out that his answers represent his personal point of view and not that of the Ministry, since the Ministry is political. He is positive toward the suggestion to perform LCAs on reference products, with the restriction that it may be expensive. He believes that the responsibility for such LCAs should be shared between SAF and FMV, but he does not know what will be required from SAF and FMV and whether they believe that it is practicable. If LCAs are made during the acquisition process, it is easiest if this occurs early in the process. Difficulties are the costs of such studies. Ohlin does not know whose responsibility it should be.

Summary of findings from the interviews. The general reaction to LCA as a tool in the acquisition process has been positive. All interviewees believe that environmental aspects should be included early in the acquisition process. There is currently limited use and experience of LCA within both the defence industry and the authorities and they are concerned about costs for making LCAs. However, the industry is positive about performing LCAs or contributing to LCA studies, if FMV were to require it. FMV is also positive, but indicates that SAF has to require the study. SAF is positive about LCA, provided that there is a need for an LCA study. If the Ministry of Defence were to require that SAF demand LCA information, then SAF would demand this from FMV. There is thus a need for an initiative from one or several actors to get the ball rolling. The leading actor here could be the ministry, but the authorities or the industries could also take the initiative.

Organisational aspects. The Swedish Armed Forces places orders at the Swedish Defence Materiel Administration and thus has a key role in formulating requirements for the defence materiels.

It is interesting to note that both SAF and the Ministry of Defence deal with acquisition issues with very little interaction from groups working with environmental issues. In order to integrate environmental aspects in general, and life-cycle thinking in particular, an integration of the environmental and acquisition parts of the organisations would probably be necessary.

5 Discussion

Procurement in public and non-public organisations has the potential to influence product development towards more environmentally preferable products. In order not to miss essential aspects, it is important to have a life-cycle perspective. We believe that Life Cycle Assessments, simplified or comprehensive quantitative ones, are appropriate for this purpose. It is advantageous to use internationally accepted methods, like LCA, in order to communicate the results with organisations from other countries. Swedish acquisition of defence materiel is becoming more and more internationalised. Acquisition in the Swedish defence sector can include the actual production process; therefore it is an advantage that LCAs are commonly used for environmentally preferable production.

Many of the interviewees suggest that environmental matters should be taken into consideration early in the acquisition process, since it is easiest to influence the product early in the process. Difficulties with our suggestions are for example cost, time, knowledge, difficulties of tracing data, and the lack of integration of environmental questions into other activities of the involved organisations. Environmental considerations with a life-cycle perspective would be facilitated if the procuring and environmental units, in this case at FMV, SAF and the Swedish Ministry of Defence, could cooperate more. Although none of the interviewees work with LCAs today, some of them are familiar with the method and stress the importance of a simplified approach. The term 'life-cycle' is often used by the actors, and sometimes with a different meaning than for LCAs, as discussed above. LCCs are used for procurement purposes in Swedish defence today, but without including environmental costs. In order to consider the whole life-cycle cost, environmental costs should be included when making an LCC analysis. It may be discussed whether external costs should be included in LCC. Reasons to include external costs can be that the company wants to take responsibility for society or that there is a risk that the costs will be laid on the company because of political decisions (i.e. that the external cost will be internalised, see for example Rebitzer and Hunkeler 2003). These issues need to be studied more in the future. Results from an environmentally extended LCC analysis, an LCA and/or an MECO analysis should be used when setting environmental requirements on materiel procurement. Such results should also be used when designing, developing and deciding on disposal strategies for defence materiel.

6 Conclusions

Methodology recommendations for quantitative, comprehensive LCA and simplified LCA have been presented in this article, as well as suggestions on how to integrate LCA methods in the acquisition process.

We have identified four areas for the use of LCA in the acquisition process: learning about environmental aspects of the product; fulfilling requirements from customers; setting environmental requirements; and choosing between alternatives. For choosing between alternatives, a quantitative LCA should be used, since a quantitative dimension is needed in order to compare alternatives.

We have suggested that the defence sector should work systematically through different product groups. For each product group, quantitative, traditional LCAs or simplified LCAs (in this case MECOs) should be performed for reference products within each product group. LCAs can also be performed during the actual acquisition process.

From the interviews it has become clear that the actors in the acquisition process think that environmental aspects should be included early in the process. The actors are interested in using LCA methods, but there is a need for an initiative from one or several of them if the method is to be used regularly in the process. An integration of environmental and acquisition parts in the controlling and ordering organisations is probably needed in order to integrate environmental aspects in general and life-cycle thinking in particular.

Acknowlegements. Financial support from the Swedish Armed Forces is gratefully acknowledged. This paper draws on data partly presented in a longer report (Hochschorner and Finnveden 2004). We are grateful to Henrikke Baumann from Chalmers University of Technology and others attending the seminar where the report was discussed for their valuable comments. Thanks also to all interviewees and reviewers, especially Anna Björklund and Diane Pecorari from KTH, for their contributions.

References

Baldo G, Rollino S, Stimmeder G, Fieschi M (2002): The use of LCA to develop eco-label criteria for hard floor coverings on behalf of the European Flower. Int J LCA 7, 269–275

Baumann H, Tillman A-M (2004): The Hitch Hiker's Guide to LCA: An orientation in life cycle assessment methodology and application. Studentlitteratur, Lund

Byggeth S, Hochschorner E (2005): Handling trade-offs in Ecodesign tools for sustainable product development and procurement. Journal of Cleaner Production. In press (Online publication)

Bocksteal NE, Freeman III AM, Kopp RJ, Portney PR, Smith VK (2000): On measuring economic values for nature. Environ Sci Technol 34, 1384–1389

Chen C (2005): Incorporating green purchasing into the frame of ISO 14000. Journal of Cleaner Production 13 (2005) 927–933

Christiansen K (ed) (1997): Simplifying LCA: Just a Cut? Final report from the SETAC-EUROPE LCA Screening and Streamlining Working Group, Brussels

COM – Commission of the European Communities (2001a): Commission interpretative communication on the Community law applicable to public procurement and the possibilities for integrating environmental considerations into public procurement. COM (2001) 274 final, Brussels

COM – Commission of the European Communities (2001b): Green Paper on Integrated Product Policy. COM (2001) 68 final, Brussels

COM – Commission of the European Communities (2003): Communication from the Commission to the council and the European Parliament. Integrated Product Policy, Building on Environmental Life-Cycle Thinking. COM (2003) 302 final, Brussels

CWRT – Center for Waste Reduction Technologies (2000): Total Cost Assessment Methodology. American Institute of Chemical Engineers, New York

Defense Acquisition University (2001): Introduction to Defense Acquisition Management. Virginia

Edesgård M, Eriksson L (1999): Miljöanpassad Produktutveckling, Livscykelanalys på 40/48 kulsgr 95LK(3P). Institutionen för ingenjörsvetenskap, fysik och matematik, Karlstad University, Karlstad (in Swedish)

Faith-Ell C (2005): The application of environmental requirements in procurement of road maintenance in Sweden. Doctoral Thesis, Royal Institute of Technology, Stockholm

Finnveden G, Östlund P (1997): Exergies of natural resources in life-cycle assessment and other applications. Energy 22, 923–931

Finnveden G, Wadeskog A, Eriksson BN, Johansson J, Palm V, Åkerman J, Hedberg L (2002): Indirekt miljöpåverkan från försvarssektorn. FOI-R-0368-SE, FOI, Stockholm (in Swedish)
Finnveden G, Björklund A, Carlsson Reich M, Ericsson O, Sörbom A (2005): Robusta och flexibla strategier för nyttjande av energi ur avfall. TRITA-INFRA-FMS 2005: 2, fms, KTH. Stockholm (in Swedish)
FMV (1999): Förstudie vid FMV: Integrering av miljökostnader I LCC (Life Cycle Cost) och användning av LCA (Life Cycle Assessment). Sweden (in Swedish)
FMV (2002): Silverbibeln 020910. Sweden (in Swedish)
FMV (2003): Restriktionslistan. Sweden (in Swedish)
Graedel TE, Allenby BR (1995): Industrial Ecology. Prentice Hall, New Jersey
Graedel TE (1998): Streamlined Life-Cycle Assessment. Prentice Hall, New Jersey
Guinée JB, Gorrée M, Heijungs R, Huppes G, Klejn R, Koning A de, Oers L van, Wegener Sleeswijk A, Suh S, Udo de Haes HA, Brujin H de, Duin R van, Huijbrects MAJ (2002): Handbook on Life Cycle Assessment. Operational Guide to the ISO Standards. Kluwer Academic Publishers, Dordrecht
Hochschorner E, Finnveden G (2003a): Evaluation of two simplified Life Cycle Assessment methods. Int J LCA 8, 119–128
Hochschorner E, Finnveden G (2003b): Use of Life Cycle Assessment Methodology in the Acquisition Process of Defence Materiel. FOI-R-0786-SE, Stockholm. The report is available at <http://www.infra.kth.se/fms/>
Hochschorner E, Finnveden G (2004): Environmental Life Cycle Methods in Acquisition of Defence Materiel. FOI-R-1384-SE, Stockholm. The report is available at <http://www.infra.kth.se/fms/>
Hochschorner E, Hägvall J, Finnveden G, Griffing E, Overcash M (2005): Environmental Life Cycle Assessment of a Pre Fragmented High Explosive Grenade. Journal of Chemical Technology & Biotechnology (accepted for publication)
ISO (1997): Environmental Management – Life Cycle Assessment – Principles and Framework. ISO14040:1997
ISO (1998): Environmental Management – Life Cycle Assessment – Goal and Scope Definition and Inventory analysis. ISO 14041:1998
ISO (2000a): Environmental Management – Life Cycle Assessment – Life Cycle Impact Assessment. ISO 14042:2000
ISO (2000b): Environmental Management – Life Cycle Assessment – Life Cycle Interpretation. ISO 14043:2000
Johansson J, Finnveden G, Moberg Å (2001): Metoder för förenklade, kvalitativa livscykelanalyser av produkter och materiel. FOI-R-0032-SE, Stockholm (in Swedish)
Jonsson A (2004): Miljöhänsyn i statliga ramavtal. Naturvårdsverket (Swedish EPA)
Kemikalieinspektionen (2004): Klassificeringslistan, KIFS 2001:3 and KIFS 2002:3, available at <http://www.kemi.se>
Lindfors L-G, Christiansen K, Hoffman L, Virtanen Y, Juntilla V, Hanssen O-J, Rönning A, Ekvall T, Finnveden G (1995): Nordic Guidelines on Life-Cycle Assessment. Nordic Council of Ministers, Copenhagen
Lippiat B, Boyles A (2001): Using BEES to select cost-effective green products. Int J LCA 6, 76–80
Nordic Council of Ministers (2004): N-Class Database on Environmental Hazard Classification. Version 5.0, available at <http://www.kemi.se/nclass/default.asp>
OECD, Organisation for Economic Co-operation and development (2000): Greener Public Purchasing: Issues and Practical Solutions. Paris
Pommer K, Bech P, Wenzel H, Caspersen N, Olsen SI (2001): Håndbog i miljøvurdering af produkter – en enkel metode. Miljønyt Nr. 58 2001. Miljøstyrelsen, Miljø – og Energiministeriet. Denmark (in Danish)
Rebitzer G, Hunkeler D (2003): Life Cycle Costing in LCM: Ambitions, opportunities, and limitations – Discussing a framework. Int J LCA 8 (5) 253–256
SAF, the Swedish Armed Forces (1997): Försvarsmaktens målsättningsarbete, H MÅL (In Swedish)
SAF, the Swedish Armed Forces (2001): Miljöanpassad försörjning av försvarsmateriel (in Swedish)
Senthil KD, Ong SK, Nee AYC, Tan RBH (2003): A proposed tool to integrate environmental and economical assessments of products. Environmental Impact Assessment Review, 51–72
SCB (2004): Statistics Sweden <http://www.scb.se/>
SOU (2001): Försvarsmateiel på nya villkor. Stockholm (in Swedish)
Steen B (1999): A Systematic Approach to Environmental Priority Strategies in Product Development (EPS). Version 2000 – Models and data of the default method. CPM, Chalmers, Gothenburg
Swedish EPA (Environmental Protection Agency) (2005): Miljöanpassad offentlig upphandling. En enkätstudie 2004, Rapport 5445, Naturvårdsverket (Swedish EPA) (in Swedish)
The European Green Purchasing Network (2003): Green Purchasing in Europe. In: The EPE Workbook Series. European Partners for the Environment <http://www.epe.be>
Todd JA, Curran MA (eds) (1999): Streamlined Life-Cycle Assessment: A Final Report from the SETAC North America Streamlined LCA Workgroup. Society of Environmental Toxicology and Chemistry (SETAC) and SETAC Foundation for Environmental Education
Turner RK, Pearce D, Bateman I (1994): Environmental Economics, an Elementary Introduction. Harvester Wheatsheaf, Hemel Hempsted
Wenzel H, Hauschild M, Alting L (1997): Environmental Assessment of Products. Volume 1: Methodology, Tools and Case Studies in Product Development, Vol 1, Chapman & Hall, London
Wenzel H (1998): Application Dependency of LCA Methodology: Key Variables and Their Mode of Influencing the Method. Int J LCA 3 (5) 281–288
Woodward DG (1997): Life cycle costing – Theory, information acquisition and application. International Journal of Project Management 15, 335–344

Personal communications

Algotsson K (2003): Environmental Director, Saab AB
Ericson E, Svedlund T (2003): Environmental unit, Alvis Hägglunds AB
Hull O (2003): Order unit, Swedish Armed Forces
Hägvall J (2005): Weapons and Protection, Swedish Defence Research Agency
Kinell L (2003): System security, Bofors Defence AB. Personal comments
Ohlin H (2003): Military unit, Swedish Ministry of Defence
Wendel M (2003): Swedish Defence Materiel Administration, FMV
Overcash M (2003): North Carolina State University

Received: October 22nd, 2004
Accepted: October 21st, 2005
OnlineFirst: October 22nd, 2005